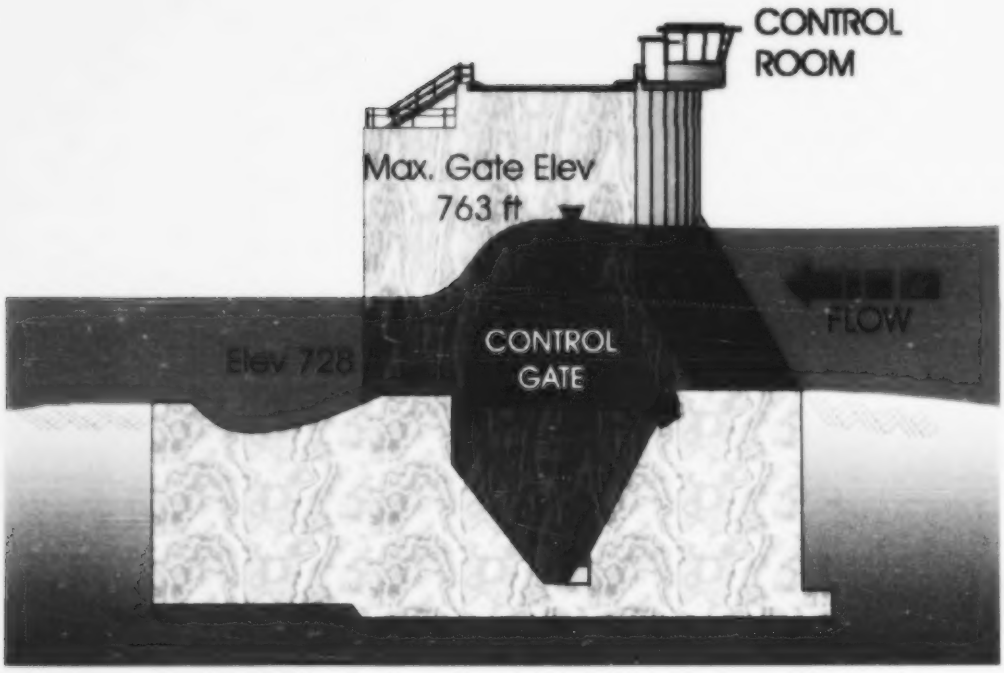
Red River Floodway Operation Report

Spring 2007



THE RED RIVER FLOODWAY
INLET CONTROL STRUCTURE

SUBMITTED TO:
The Hon. Christine Melnick, Minister
Manitoba Water Stewardship

SUBMITTED BY:
Water Science and Management Branch
Ecological Services Division
Manitoba Water Stewardship

July 3, 2007

Manitoba

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July 3, 2007

The Honorable Christine Melnick, Minister
Manitoba Water Stewardship

Dear Minister Melnick:

I am pleased to provide a report documenting the 2007 spring operation of the Red River Floodway. The *Red River Floodway Act* requires that a report be presented to the Minister of Water Stewardship by June 30 in any year in which the floodway is operated during the spring runoff period. In 2007 the floodway was operated from April 3 until April 17. This report documents that operation.

Don Norquay, Assistant Deputy Minister

c: Dwight Williamson

FOREWORD

From its completion in 1968 until 2007, the Red River Floodway has been operated in 26 of the intervening years. Operation of the floodway has saved many millions of dollars in damage in the City of Winnipeg. However, on occasion the operation has aggravated flooding outside of the City of Winnipeg.

In 2005 the *Red River Floodway Act* was proclaimed. Clause 11(1) of this Act requires the preparation of a report detailing spring floodway operation and determining if the operation caused Red River levels at the floodway channel inlet to exceed the computed natural level. The following report details the operation of the Red River Floodway in the spring runoff period of 2007.

All flows and levels in this report are shown in imperial units. Flows can be converted from cubic feet per second (cfs) to cubic metres per second (m^3/s) by dividing by 35.3148. River levels can be converted from feet to metres by dividing by a factor of 3.28084. Water Survey of Canada is acknowledged for providing the provisional flows used in the report.

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INTRODUCTION

During the spring of 2007 the Red River Floodway was operated during the period from 9:30 AM on April 3 to 8:25 AM on April 17. Table 1 lists all of the gate operations during that period. The peak recorded level at the floodway entrance (Water Survey of Canada station 05OC026) was 753.86 feet at 7:00 AM on April 10. The computation of the natural level is described in a later section of the report.

Table 1 – April 2007 Floodway Gate Operations

Date	Time*	Start of Operation	End of Operation
April 3, 2007	9:30 AM	728.04	737.09
April 3, 2007	9:30 PM	737.09	737.47
April 4, 2007	2:30 PM	737.47	737.95
April 5, 2007	10:25 AM	737.95	737.47
April 6, 2007	1:05 PM	737.47	737.19
April 7, 2007	10:35 AM	737.19	736.90
April 8, 2007	10:15 AM	736.90	736.62
April 8, 2007	11:05 PM	736.62	736.33
April 9, 2007	10:40 AM	736.33	735.95
April 9, 2007	10:35 PM	735.95	735.58
April 11, 2007	10:10 AM	735.58	737.57
April 11, 2007	5:10 PM	737.57	739.29
April 12, 2007	10:30 PM	739.29	739.00
April 13, 2007	11:30 AM	739.00	738.71
April 13, 2007	11:10 PM	738.71	738.14
April 14, 2007	10:45 AM	738.14	737.38
April 15, 2007	12:05 AM	737.38	737.00
April 15, 2007	12:05 PM	737.00	736.71
April 16, 2007	3:05 PM	736.71	735.01
April 16, 2007	4:30 PM	735.01	733.15
April 17, 2007	8:25 AM	733.15	728.04

* Time of start of gate operation

During this period of operation, the approved rules of operation were followed in adjusting the gates. The rules are listed in Appendix A.

2007 SPRING RUNOFF

The 2007 spring runoff and flood on the Red River was close to average in magnitude at most locations and the crest during early April was one of the earliest on record. The exception was the portion from Lockport to Selkirk where high levels were recorded due to a massive ice jam at the City of Selkirk. The crest at Selkirk was the highest on record, somewhat exceeding a previous high crest from an ice jam in 1996 and significantly exceeding the crest from the flood-of-the-century in 1997. The peak water level recorded in the City of Winnipeg on April 10 was near the flood stage of 18 feet and was associated with a release of minor ice jams at the Ste. Agathe and St. Adolphe bridges. While serious flooding occurred in the Selkirk area, little or no flooding occurred elsewhere, with only minor flooding from St. Jean to just south of Morris for about one week near the crest. Minor flooding occurred on some western tributaries for a short time from late March to early April.

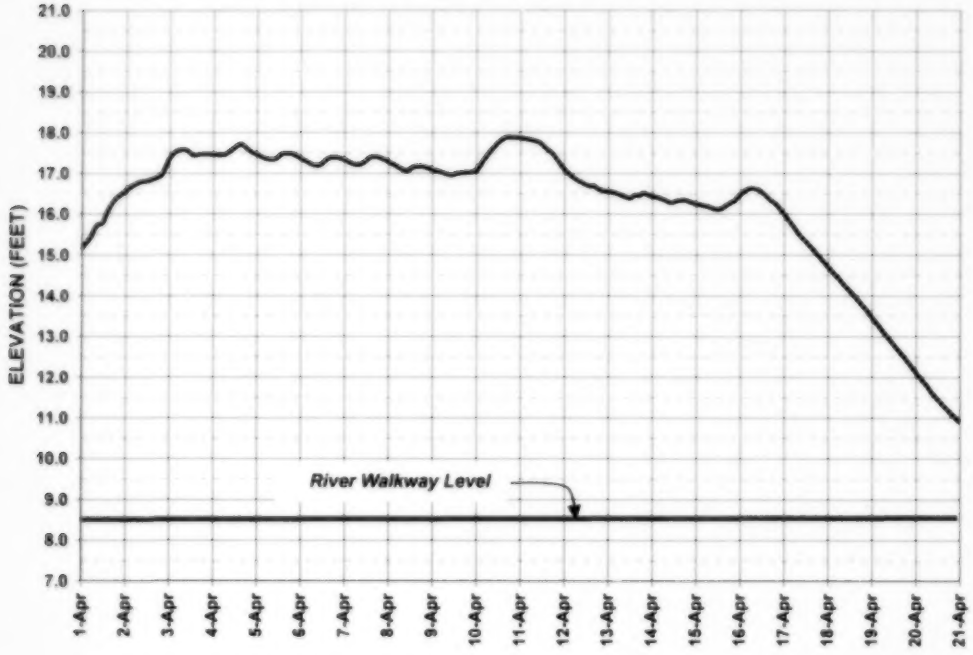
In 2007, spring runoff was average and resulted from near normal soil moisture, near normal snow cover and below average spring rain. The melt started early with no snow remaining by the end of March.

A major ice jam developed in the City of Selkirk on April 4 and remained in place until April 12, a record duration for an ice jam in the area. The associated record high water level severely flooded a marine museum, a golf course, a dozen private homes and a few condominiums in the Selkirk area. The severity and duration of the ice jam was exacerbated by unusually cold weather with wind chills of -25 C which developed when the Red River was nearing its crest during the first week of April. The cold weather lasted from April 4 to April 11 and produced large amounts of frazil ice on the Manitoba portion of the river. This added to the ice jam at Selkirk and produced a secondary frazil ice jam and associated flooding extending to at least six miles south of the main jam at Selkirk. After the ice jam dissipated on April 12, points from Selkirk north to Lake Winnipeg experienced only minor flooding for a day or so as the ice moved relatively unimpeded to the delta area south of the Lake.

The Red River Floodway was operated April 3-17 with peak diverted flows of 4500 cfs. Persistent ice conditions in the Floodway channel due to the cold weather impeded the free flow of water and made estimation of flows difficult. The peak stage at the Inlet was 753.86 feet on April 10 with an estimated peak river flow of 49,100 cfs. River flows and levels declined rapidly after April 12 due to dry weather conditions which extended until mid May.

Red River levels in Winnipeg at James Avenue during the period of operation are shown on Figure 1.

Figure 1 – Recorded River Levels at James Avenue 2007

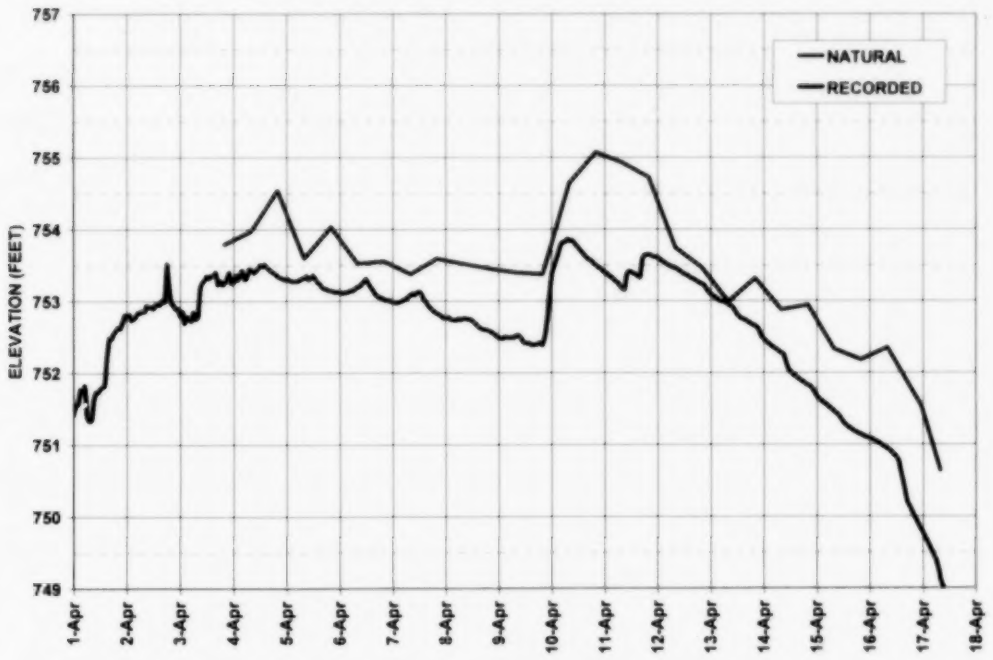


NATURAL LEVELS

The natural water level on the Red River at the Floodway entrance is defined as the water level that would have occurred at this location in the late 1950s if the flood control works had not been built. These works include Winnipeg's Primary Dykes, the Red River Floodway, the Portage Diversion, Shellmouth Reservoir, and the Assiniboine River dykes. The natural water level is the water level that is 'targeted' in the floodway operation rules, for normal floodway operation (see Appendix A). That is, during normal floodway operation, the floodway is operated so as to keep water levels on the Red River at the floodway inlet at or below the natural water level.

The recorded and natural levels at the floodway entrance are plotted in the following figure.

Figure 2 – Recorded and Natural Levels at Floodway Entrance 2007



During the 2007 spring floodway operation, the natural water levels were calculated using the relationship developed by Acres Manitoba Limited in 2004 [*"Re-Computation of Natural Water Levels at the Floodway Inlet (Final Report)", April 2004*]. This relationship requires two input values to calculate this water level. The two input values are the natural flow on the Red River downstream of the Assiniboine River (at James Avenue), and the natural flow

of the Assiniboine River into the Red River. These two input values, as well as the natural and actual water levels on the Red River at the floodway inlet, are shown for the 2007 spring flood in Table 2 below.

Table 2 – Computed 2007 Natural Flows and Levels

Date/Time	Natural Red River Flow Below Assiniboine River (cfs)	Natural Assiniboine River Flow at the Forks (cfs)	Recorded River Level at Floodway Entrance (feet)	Computed "Natural" River Level at Floodway Entrance (feet)
03-Apr-2007 8:00 AM	58,106	11,259	752.78	754.06
03-Apr-2007 8:00 PM	56,735	10,342	753.24	753.79
04-Apr-2007 8:00 PM	61,625	14,807	753.35	754.54
05-Apr-2007 8:00 PM	58,541	12,183	753.14	754.03
06-Apr-2007 8:00 PM	55,426	9,421	753.02	753.55
07-Apr-2007 8:00 PM	55,412	9,201	752.82	753.59
08-Apr-2007 8:00 PM	55,463	9,963	752.58	753.46
09-Apr-2007 8:00 PM	55,553	10,522	752.39	753.38
10-Apr-2007 8:00 PM	61,025	10,807	753.50	755.07
11-Apr-2007 8:00 PM	60,339	11,575	753.65	754.72
12-Apr-2007 8:00 PM	56,611	11,860	753.23	753.47
13-Apr-2007 8:00 PM	54,766	9,520	752.65	753.32
14-Apr-2007 8:00 PM	54,555	11,120	751.82	752.94
15-Apr-2007 8:00 PM	51,192	9,488	751.14	752.18
16-Apr-2007 11:25 PM	49,392	9,709	749.83	751.53

Appendix B contains a detailed explanation of how the natural flows in Table 2 were computed.

The recorded river level at the floodway entrance was maintained below the computed natural level an average of 0.81 feet throughout the entire period of floodway operation. However, at times, the difference was as much as 1.8 feet. The reasons for this situation are described in the next section.

OPERATIONAL ISSUES

Flow Estimation and Gate Operation

Normally, ice is gone from the main waterways before the peak. However, the presence of ice and debris made it difficult for federal and provincial hydrometric technicians to directly measure flows in the floodway channel and the river before the peak occurred at the floodway inlet and in the city on April 10.

As stated previously, a period of unusually cold weather developed when the Red River was nearing its crest during the first week of April. The cold weather lasted from April 4 to April 11 and produced large amounts of frazil ice on portions of the river. The temperatures dropped so drastically that the floodway froze over completely for a few days, making metering of flows virtually impossible. This circumstance resulted in not having good real-time flow measurement data to guide the operation of flood control works throughout most of the runoff event. Therefore, a large difference was maintained between actual and natural levels to ensure that natural levels upstream of the floodway control structure were not exceeded.

Gate Operations

This spring gate operations were made to follow the natural rise in water levels through a series of small steps. This was done to address concern about large gate raises causing sudden sharp changes in water levels above and below the floodway control structure. The average gate adjustment was 0.69 feet during the period that floodway flows were affected by gate operation.

CONCLUSIONS

Operation of the Red River Floodway inlet control structure during the spring of 2007 resulted in a peak river level at the floodway entrance of 753.86 feet, which was 1.21 feet lower than the computed natural peak level of 755.07 feet. The recorded river level at the floodway entrance was maintained below the computed natural level an average of 0.81 feet throughout the entire period of floodway operation. However, the difference was as much as 1.8 feet at times. At no time during floodway operation in the spring of 2007 did levels exceed the computed natural level.

APPENDIX A

Red River Floodway Rules of Operation

Rules of Operation
Red River Floodway Control Structure

Normal Operation:
1. Maintain natural[1] water levels on the Red River at the entrance to the floodway channel, until the water surface elevation at James Avenue reaches 24.5 feet (7.46 metres), or the river level anywhere along the Red River within the City of Winnipeg reaches two feet below the Flood Protection Level of 27.83 feet (8.48 m).

Major Flood Operation:
2. Once the river levels within Winnipeg reach the limits described in Rule 1, the level in Winnipeg should be held constant while levels south of the control structure continue to rise. Furthermore if forecasts indicate that levels at the entrance to the floodway channel will rise more than two feet (0.6 metres) above natural, the City of Winnipeg must proceed with emergency raising of the dikes and temporary protection measures on the sewer systems in accordance with the flood level forecasts within Winnipeg. The levels in Winnipeg should be permitted to rise as construction proceeds, but not so as to encroach on the freeboard of the dikes or compromise the emergency measures undertaken for protecting the sewer systems. At the same time the Province should consider the possibility of an emergency increase in the height of the floodway embankments and the West Dike. At no time will the water level at the floodway channel's entrance be allowed to rise to a level that infringes on the allowable freeboard on the floodway west embankment (Winnipeg side) and the West Dike.

Extreme Flood Operation:
3. For extreme floods, where the water level at the floodway channel's entrance reaches the maximum level that can be held by the floodway west embankment and the West Dike, the river level must not be permitted to exceed that level. All additional flows must be passed through Winnipeg.

Initial Gate Operation with Ice:
The floodway gates should not be operated until ice on the river is flowing freely, unless flooding in Winnipeg is imminent.

Final drop of Gates:
To minimize bank slumping along the river in Winnipeg and at the same time reduce the probability of sewer backup problems, final gate operations, once the level at the entrance to the floodway channel recedes to elevation 752 feet (229 metres), shall be carried out in consultation with the City of Winnipeg.

Operation of Horn:
The horn at the floodway structure shall only be operated once, before the first gate operation of the year. The horn should be sounded a half-hour before the first gate operation to alert residents that the floodway structure is being put into operation. For ongoing information a 1-800 number should be established that would provide current information of gate operations, potential impacts on water levels, and forecasts for the next few days. The information should also be included on the existing Water Stewardship internet site.

[1] The term natural refers to the level that would have occurred in the absence of the flood control works, with the level of urban development in place at the time of the construction of these works.

Emergency Operation to Reduce Sewer Backup in Winnipeg

4(1) This rule defines the circumstances under which the Minister of Water Stewardship ("the Minister") may determine that emergency operation of the floodway is necessary to prevent widespread basement flooding and resulting risk to health and damage to property within the City of Winnipeg.

4(2) This rule applies after the spring crest from snowmelt runoff at Winnipeg, whenever high river levels substantially impair the capacity of Winnipeg's combined sewer system.

4(3) As long as the Department of Water Stewardship ("the Department") forecasts that river levels for the next 10 days will be below 14 feet James Avenue Pumping Station Datum (JAPSD), the Department will not operate the floodway control structure.

4(4) When the Department forecasts that river levels for the next 10 days are expected to rise to 14 feet JAPSD or higher, the Department will prepare a report that describes:

(a) The basis of the Department's river level forecasts and its risk assessment;

(b) The risk of basement flooding in Winnipeg, including the following factors:

(i) The predicted peak river level in the next 10 days;

(ii) The length of time the Department forecasts the river level will be at 14 feet JAPSD or higher;

(iii) The risk of an intense rainfall event in Winnipeg in the next 10 days;

(c) The benefits and costs of floodway operation, including:

(i) The extent of basement flooding and damage to property expected from various combinations of intense rainfall events and high river levels;

(ii) The risk to the health of Winnipeg residents from sewer back-up;

(iii) Economic loss and damage caused by artificial flooding south of the inlet control structure;

(iv) Impacts of operation on fish and wildlife and their habitat and on water quality;

(v) The risks and potential costs of riverbank instability that may be caused by artificial river level changes, both upstream and downstream of the inlet control structure;

(vi) During construction of the floodway expansion, costs and risks associated with any resulting delays of that construction, including the potential average annual expected damages associated with an additional period of risk of a flood event that would exceed the current capacity of the floodway;

(vii) Such other benefits and costs of operation of which the Department is aware at the time of the preparation of the report, excluding benefits associated with recreational or tourism activities or facilities; and

(d) measures that may be taken to mitigate the costs and impacts of the operation under consideration, including:

(i) minimizing the rate at which river levels are changed both upstream and downstream of the floodway inlet control structure;
(ii) providing means to assure fish passage.

4(5) The Department will present a draft of the report prepared under rule 4(4) to the Floodway Operation Review Committee and provide an opportunity for the Committee to provide input, before finalizing the report and making recommendations respecting floodway operation.

4(6) The Department will not recommend operation of the floodway unless the expected benefits of doing so clearly and substantially outweigh the expected costs.

4(7) The Department will present its report and recommendations to the Minister, who, subject to rule 4(8), will make a decision respecting floodway operation based on his or her consideration of the report.

4(8) The Department will not operate the floodway control structure under this rule:

(a) to raise river levels immediately upstream of the control structure to an elevation higher than 760 feet above sea level;

(b) to achieve a river level of less than 9 feet JAPSD; or

(c) except in circumstances of extreme urgency, to lower river levels more than one foot per day.

4(9) The Department will issue a news release announcing a decision to operate the floodway at least 24 hours before commencing operation.

4(10) The Department will ensure every reasonable effort is made to personally notify landowners who may be directly affected by flooding due to floodway operation in advance of the operation.

4(11) The Department will sound the horn at the floodway inlet control structure one-half hour before operation commences.

4(12) The Department will maintain a program of compensation for damages suffered by landowners arising from flooding caused by floodway operation under this rule.

APPENDIX B

Computation of Natural Flows and Levels

Computation of Natural Flows and Levels On the Red and Assiniboine Rivers

Table 2 in the main report lists the natural flows on the Red River below the confluence with the Assiniboine River and on the Assiniboine River at the Forks. This Appendix describes how those flows were determined, and explains how the relationships developed in the Acres 2004 study were applied to compute the natural level at the floodway entrance.

Table B-1 lists the recorded and computed flows and levels for each time step. Columns 1 to 7 list the flows used in computing the natural flows on the Assiniboine River, and columns 8 to 10 list the flows used for computing the natural flows on the Red River.

NATURAL ASSINIBOINE RIVER FLOW

The natural flows on the Assiniboine River are altered by operation of the Shellmouth Dam, the Portage Diversion, and by the presence of dykes along the Assiniboine River.

The Shellmouth Dam can decrease flows below natural by adjusting the control gates so that reservoir outflows are lower than the inflows. In this case the reservoir levels rise, and excess water is stored behind the dam.

The Portage Diversion can be used to reduce flows in the lower Assiniboine River by diverting some of the river flow north to Lake Manitoba.

The Assiniboine River dykes were constructed to prevent overflows from the river onto the surrounding lands. Because of the height of the river and the slope of the land much of this overflow did not return to the Assiniboine River. Therefore the dykes have the effect of increasing flows entering Winnipeg on the Assiniboine River during periods of high flow.

Referring to Table B-1, column 1 lists the flow reductions at Winnipeg resulting from storage behind the Shellmouth Dam. It is important to recognize that these flow changes at the dam take some time to reach Winnipeg. The Department uses the Muskingum routing procedure to compute this flow attenuation.

Column 2 shows the flows diverted to Lake Manitoba via the Portage Diversion. Again the flows are routed to Winnipeg to apply the time delay.

Column 3 shows the recorded flows at the hydrometric station at Headingley. These first three columns are summed to determine the total natural flow before applying the natural breakouts that would have occurred if the dykes were not in place.

Column 4 lists the computed breakouts that would have occurred at those flows if the dykes had not been constructed.

Column 5 lists the computed natural flows at Headingley. These are computed by adding the three adjustments to the recorded flows at Headingley.

There is some additional local inflow entering the Assiniboine River between Headingley and the Forks. Most of this flow is recorded on Sturgeon Creek. In column 6 the recorded flows on Sturgeon Creek are increased to include unmeasured local inflows.

Finally columns 5 and 6 are added together to give the computed natural flows of the Assiniboine River at the Forks, as listed in column 7.

NATURAL RED RIVER FLOW

On the Red River the primary flow adjustment is caused by the Red River Floodway. During periods of extensive flooding there can also be a flow change resulting from changes in the storage of floodwaters on the land, but as long as flood levels at the floodway entrance are held at natural that change would be negligible.

Column 8 lists the recorded flows in the floodway channel, and column 9 shows the recorded flows at James Avenue. Column 10 sums the flows in those two columns and adds the three flow adjustments on the Assiniboine River to give the total natural flow on the Red River at James Avenue, which is downstream of the Forks.

NATURAL RIVER LEVELS AT THE FLOODWAY INLET

Table B-2 is a reproduction of Table 4-7 from the Acres report *"Re-Computation of Natural Water Levels at the Floodway Inlet (Final Report), April 2004"*. The table provides natural elevations at the inlet based upon the relative contribution of natural flow at the Forks from the Red and Assiniboine Rivers. The *combined* flow is represented by the values in the left-hand column entitled Red River at James Avenue. The Assiniboine River Contribution amount is shown across the top and is the flow in the Assiniboine River at the Forks.

The natural water level at the inlet can vary by a few feet dependent upon the amount of flow coming from the Assiniboine River (Assiniboine River Contribution). This phenomenon is referred to as a variable backwater effect.

This concept can be illustrated by using the example of 100,000 cfs flow for the Red River at James Avenue in various combinations of Red and Assiniboine River flows. One combination could have 95,000 cfs as Red River flow upstream of the Forks and 5,000 cfs as Assiniboine River Contribution; this combination results in a level at the inlet of 765.6 feet as shown in Table B-2. Similarly, another combination, while still yielding a total James Avenue flow of 100,000 cfs, could be 70,000 cfs as Red River flow upstream of the Forks and 30,000 cfs as Assiniboine River Contribution; the resulting inlet level would be 762.9 feet. The difference in the inlet water elevation between these two flow combinations is 2.7 feet, with the lower elevation occurring when there is relatively more flow on the Assiniboine River.

Natural levels are determined by using the natural Red River flows at James Avenue listed in column 10 of Table B-1, and the natural Assiniboine River flows listed in column 7 of Table B-1 and interpolating between the values listed in Table B-2 to determine the natural levels. These natural levels are listed in column 11 of Table B-1. For comparison, column 12 of Table B-1 lists the recorded levels at the floodway inlet (station 05OC026).

Table B-1 Spring 2007 Flows and Levels

Column =>	1	2	3	4	5	6	7	8	9	10	11	12
	Assiniboine Flows							Red River Flows				
	Shellmouth Flow Changes (Routed to Headingley)	Portage Diversion flow (Routed to Headingley)	Actual Assiniboine R. flow at Headingley	Natural breakouts from river	Natural Assiniboine River flow at Headingley	Sturgeon Cr. Flow plus other local inflows	**Natural Assiniboine R. flow into Red River**	Red River Floodway flow	Red River flow at James Ave.	**Natural Red River flow at James Avenue**	Natural water level on Red R. at Floodway Inlet (feet)	Recorded Water level on Red R. at Floodway Inlet (feet)
Date / Time	*Recorded*	*Recorded*	*Recorded*	*Computed*	*=1+2+3-4*	*Rec. & Est.*	**=5+6**	*Recorded*	*Recorded*	***=1+2-4+8+9***	*Computed*	*Recorded*
03/Apr/2007 8:00 AM	-1410	6,815	5,098	0	10,503	755	**11,259**	1,112	51,589	**58,106**	754.06	752.78
03/Apr/2007 8:00 PM	-1410	5,820	5,342	0	9,752	590	**10,342**	1,112	51,212	**56,735**	753.79	753.24
04/Apr/2007 8:00 AM	-1407	5,877	5,476	0	9,946	475	**10,421**	1,593	51,297	**57,360**	753.98	753.44
04/Apr/2007 8:00 PM	-1400	9,940	5,603	0	14,143	663	**14,807**	1,593	51,492	**61,625**	754.54	753.35
05/Apr/2007 8:00 AM	-1395	5,559	5,500	0	9,664	723	**10,387**	1,275	50,715	**56,153**	753.60	753.32
05/Apr/2007 8:00 PM	-1380	7,494	5,367	0	11,481	701	**12,183**	1,275	51,152	**58,541**	754.03	753.14
06/Apr/2007 8:00 AM	-1364	6,409	5,395	0	10,440	594	**11,034**	1,123	50,156	**56,324**	753.53	753.20
06/Apr/2007 8:00 PM	-1330	4,761	5,409	0	8,840	581	**9,421**	1,123	50,872	**55,426**	753.55	753.02
07/Apr/2007 8:00 AM	-1300	4,395	5,384	0	8,479	568	**9,047**	1,314	50,241	**54,650**	753.38	753.08
07/Apr/2007 8:00 PM	-1260	4,559	5,335	0	8,633	568	**9,201**	1,314	50,800	**55,412**	753.59	752.82
08/Apr/2007 8:00 AM	-1220	6,039	5,428	0	10,247	505	**10,752**	1,554	49,756	**56,128**	753.52	752.76
08/Apr/2007 8:00 PM	-1165	5,063	5,517	0	9,415	547	**9,963**	1,554	50,011	**55,463**	753.46	752.58
09/Apr/2007 8:00 AM	-1110	5,776	5,666	0	10,333	494	**10,827**	1,776	49,356	**55,799**	753.40	752.52
09/Apr/2007 8:00 PM	-1060	5,275	5,759	0	9,974	548	**10,522**	1,776	49,561	**55,553**	753.38	752.39
10/Apr/2007 8:00 AM	-985	4,872	5,866	0	9,753	485	**10,238**	3,920	51,540	**59,347**	754.65	753.84
10/Apr/2007 8:00 PM	-920	5,284	5,926	0	10,289	518	**10,807**	3,920	52,742	**61,025**	755.07	753.50
11/Apr/2007 8:00 AM	-856	4,937	5,947	0	10,028	500	**10,528**	3,920	52,402	**60,403**	754.93	753.17
11/Apr/2007 8:00 PM	-789	5,939	5,891	0	11,040	535	**11,575**	4,500	50,690	**60,339**	754.72	753.65
12/Apr/2007 8:00 AM	-723	4,822	6,003	0	10,102	620	**10,722**	4,059	48,661	**56,820**	753.75	753.46
12/Apr/2007 8:00 PM	-654	5,933	6,015	0	11,294	567	**11,860**	3,537	47,795	**56,611**	753.47	753.23
13/Apr/2007 8:00 AM	-585	5,012	6,078	0	10,505	532	**11,037**	3,008	47,230	**54,665**	753.00	752.95
13/Apr/2007 8:00 PM	-510	5,260	4,363	0	9,113	407	**9,520**	2,536	47,480	**54,766**	753.32	752.65
14/Apr/2007 8:00 AM	-435	4,964	4,363	0	8,892	339	**9,231**	1,970	46,719	**53,218**	752.88	752.28
14/Apr/2007 8:00 PM	-350	6,790	4,363	0	10,802	317	**11,120**	1,423	46,692	**54,555**	752.94	751.82
15/Apr/2007 8:00 AM	-266	4,318	4,363	0	8,415	323	**8,738**	1,038	46,089	**51,179**	752.33	751.46
15/Apr/2007 8:00 PM	-170	4,124	5,204	0	9,158	331	**9,488**	546	46,692	**51,192**	752.18	751.14
16/Apr/2007 8:00 AM	-70	3,988	6,173	0	10,091	372	**10,463**	441	47,952	**52,311**	752.35	750.94
16/Apr/2007 11:25 PM	70	3,595	5,611	0	9,276	433	**9,709**	31	45,695	**49,392**	751.53	749.83
17/Apr/2007 8:00 AM	150	3,139	5,572	0	8,861	536	**9,398**	0	43,503	**46,792**	750.64	749.10

Table B-2 Red River Floodway Inlet Natural Rating Table

RED RIVER AT JAMES AVENUE (cfs)	ASSINIBOINE RIVER CONTRIBUTION (cfs)										
cfs	0	5,000	10,000	15,000	20,000	25,000	30,000	35,000	40,000	45,000	50,000
20,000	742.1	740.4	738.7	737.4							
30,000	746.6	745.2	743.9	742.6	741.5						
40,000	750.4	749.2	748.0	746.9	745.8	744.9					
50,000	753.8	752.7	751.7	750.7	749.7	748.8	747.9				
60,000	756.8	755.9	754.9	754.0	753.1	752.2	751.4				
70,000	759.7	758.8	758.0	757.1	756.3	755.5	754.7				
80,000	762.4	761.6	760.8	760.1	759.3	758.5	757.8				
90,000		763.9	763.2	762.6	761.9	761.2	760.6	759.9			
100,000		765.6	765.3	764.8	764.1	763.5	762.9	762.3			
110,000		766.7	766.3	765.9	765.5	765.2	764.7	764.2			
120,000		767.6	767.5	767.2	766.8	766.5	766.1	765.7	765.4		
130,000		768.5	768.2	768.0	767.7	767.5	767.3	767.0	766.6		
140,000			768.7	768.7	768.6	768.4	768.1	767.9	767.6	767.4	
150,000			769.1	769.0	768.8	768.7	768.6	768.5	768.5	768.3	
160,000			769.6	769.4	769.2	769.1	768.9	768.8	768.7	768.5	768.5
170,000			770.1	769.9	769.8	769.6	769.5	769.3	769.2	769.0	768.8
180,000			770.5	770.4	770.3	770.2	770.0	769.9	769.7	769.5	769.4
190,000				770.5	770.5	770.5	770.5	770.3	770.2	770.1	769.9
200,000				770.7	770.6	770.6	770.5	770.5	770.5	770.5	770.5
210,000				770.9	770.8	770.7	770.7	770.6	770.6	770.5	770.5
220,000				771.1	771.0	770.9	770.8	770.7	770.7	770.6	770.5
230,000				771.2	771.2	771.1	771.0	770.9	770.8	770.7	770.7
240,000					771.5	771.4	771.3	771.2	771.1	771.0	770.9
250,000					771.8	771.7	771.6	771.6	771.5	771.4	771.3
260,000					772.1	772.0	772.0	771.9	771.8	771.7	771.6
270,000					772.4	772.4	772.3	772.2	772.1	772.1	772.0
280,000					772.8	772.7	772.6	772.5	772.5	772.4	772.3
290,000					773.1	773.0	772.9	772.8	772.8	772.7	772.6
300,000					773.3	773.3	773.2	773.1	773.1	773.0	772.9

Note: Open water conditions under steady state (no ice)